Chemical Engineering Division

Basic and Applied Sciences

The Chemical Engineering Division conducts research on fundamental issues that involve the performance of chemistry and materials in systems related to electric power distribution, enhanced energy efficiency, chemical manufacturing, and clean air technologies.

Catalysis is the acceleration of a chemical reaction induced by the presence of material that is chemically unchanged at the end of the reaction. We are conducting research on both homogeneous (soluble) catalysts and heterogenous (insoluble) catalysts. Catalysts of one or the other of these two types are required in more than 90% of all industrial chemical processes. Hence, catalysis research has great economic, environmental, and energy relevance. Advances in process technologies, particularly in regard to product purification, catalyst separation and recycling, often impact the relative economics of homogeneous versus heterogeneous catalysis routes for many chemicals. Homogeneous catalysis provides an excellent choice where highly specific reactions are desired, such as in olefin hydroformylation. Focus areas in heterogeneous catalysis include the development of catalysts for reducing nitrogen oxide emissions, advanced catalytic membrane reactors, and catalysis in relation to hydrogen production.

In one area of our research we are exploring the role of metal-centered free radicals in the mechanisms for the hydroformylation of olefins and the hydrogenation of carbon monoxide for the production of fuels and chemicals. We are combining nanoscience methodologies with multiphase-media approaches and surfactant technology to develop new classes of catalysts that have the combined beneficial characteristics of homogeneous and heterogeneous catalysis.

The nuclear magnetic imaging techniques developed in our catalysis program are finding broad use. Our toroid cavity imager uses nuclear magnetic resonance (NMR) technology to reveal the location and characteristics of materials near electrodes in batteries and fuel cells and inside pressure vessels and other sealed metal containers. Moisture, degradation products, and other chemical reaction products can be detected and measured nondestructively. The device's high resolution and sensitivity make it attractive for nuclear-waste monitoring, as well as for nondestructive evaluation of commercial packaged goods, and safety and security applications. This inexpensive imaging device could point the way to improved ceramics, alloys, composites and coatings and could permit more detailed observations than ever before of the chemical near the surface of electrodes in batteries, fuel cells and similar devices.

Scientists at Argonne have started work that could provide clean, renewable fuels for transportation using a variety of feedstocks. Here, chemist Jeffrey Elam (Energy Systems Division) holds a prototype membrane that is ready to be evaluated in a catalytic testing reactor operated by chemical engineer Donald Cronauer (Chemical Engineering Division).

Aluminum nanoparticles have attracted interest as building blocks for high-capacity hydrogen storage materials. We have produced the first stable dispersions of aluminum nanoparticles by protecting them against agglomeration using a unique polymer coating. The reactivity of the nanoparticles is probed using a range of powerful solution phase spectroscopic methods. We have observed the first examples of a plasmon resonance for aluminum nanoparticles.

One of the main challenges in the field of homogeneous catalysis lies in reducing the cost associated with separating the reaction products from the soluble catalysts. Toward the end, we are developing magnetically recoverable catalysts. Our initial work has focused on soluble ferromagnetic cobalt nanoparticulate catalysts that can be isolated from the solution phase at the end of the reaction by the use of a conventional magnet. In addition, we are interested in dispersions of metal nanoparticles as a route to bridge the gap between homogeneous and heterogeneous catalysts.

We also are investigating high-temperature superconducting (HTS) ceramics for electric power, focusing on the optimization of processing conditions for the Ag/Bi-2223 composite superconductor and the characterization of HTS-coated conductor embodiments employing biaxially textured $Y_1Ba_2Cu_3O_7$.

For More Information

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